artment of Agriculture Agricultural Research Service

March 1992

Agricultural Research

Now THAT'S a Tomato

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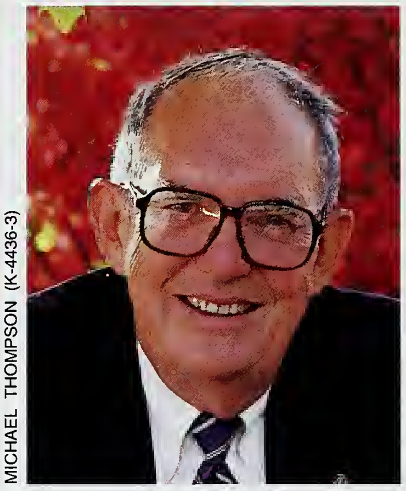
FORUM

John R. Gorham Distinguished Scientist of 1991

"For creative research and inspiring leadership resulting in solutions to problems of disease control and basic knowledge of viral and genetic diseases of humans and animals."



MICHAEL THOMPSON (K-4436-3)

But that citation barely hints at the real story behind the plaque given to Dr. Gorham for wide-ranging accomplishments over an illustrious career.

The table of organization identifies him as a veterinary medical officer at the Agricultural Research Service's Animal Disease Research Unit in Pullman, Washington, located on the campus of Washington State University. Officially, he is the eleventh annual recipient of the Distinguished Scientist Award, the top honor for scientific achievement in the U.S. Department of Agriculture.

But a look behind the scenes finds nearly 50 years of dedicated research that has improved the lives of millions of people and animals alike.

For example, his work describing the Chediak-Higashi syndrome in animals provided an important clue in the study of a devastating genetic disorder in humans. He was part of a team that first reported a viral disease of goats that causes arthritis and encephalitis. This virus disease now serves as a model for the study of arthritis and AIDS in humans.

He developed a spray vaccine for the control of distemper in mink which is used worldwide for millions of immunizations. He was also the first to discover that vitamin E prevents steatitis, a serious nutritional disease of mink, swine, and cats.

When he was a young researcher, he and a coworker discovered a new rickettsial disease of foxes and dogs that is transmitted by a small intestinal parasite.

Recently, in an interview with ARS information staffer Jim Henry, Dr. Gorham shared some personal insights into the forces that mold and motivate scientific excellence.

AR: The extensive list of your accomplishments suggests that you take a results-oriented approach toward veterinary medicine.

Gorham: Yes, it's fair to say that we're always looking for the practical application of our work. All our projects are to develop either a diagnostic test or a new vaccine—something to control disease. But in most cases it takes basic research to get there.

AR: You speak of "our projects." How does your work mesh with the work of others? Where does the collaborative process begin?

Gorham: You start out by asking a question and then go about trying to solve it. And in the process of solving it, you find good colleagues. People brighter than yourself. Then you let them alone in the lab to have fun.

AR: Fun?

Gorham: If you don't have fun doing research, you might as well go out and sell insurance or real estate. Think of research as a sport, an organized sport. You sit around on a coffee break and figure out the strategy of the research. How much money you've got to spend on the project. And then you go back and attack the project.

AR: In mapping out a research project, how do you decide on a plan of attack?

Gorham: I think you have to be flexible—just like in a football game. Sometimes you go one step at a time, like old Woody Hayes' 3 yards and a cloud of dust, again and again. Sometimes in science, one small finding follows another, again and again. But then, sometimes you can throw a pass and cover a lot of ground quickly to score a touchdown. Score a new discovery, for example. Some new contribution to the team effort.

AR: But how do you remain motivated when, as happens in science as well as football, instead of gaining ground, you seem to lose it?

Gorham: Whether you seem to be ahead of the game or not, I don't think any research worker worth his or her salt is ever satisfied. You're always looking for the next finding. Something good. This is a competitive game. Something that all researchers want more than anything else is the esteem of their peers. The esteem of your contemporaries. And how do you earn the respect of your peers? You're first. And that's what it's all about. That's the fun about research. And that's what's kept me in it almost 50 years.

Agricultural Research

Cover photo by Scott Bauer. (K-4659-1)

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SCOTT BAUER

Solid Future for Tomatoes

Breeders are producing fruit with less water, thicker juice.

Though you might not think of a tomato as watery, most ordinary tomatoes are 95 percent water.

And when you buy a tomato product—a bottle of catsup, a can of tomato soup, or a jar of spaghetti sauce—you're paying the cost of removing that water.

But tomorrow's tomatoes, says ARS scientist Merle L. Weaver, might have less water and more of the compounds called solids that processors condense at the factory. The concentrate, rich in fiber and natural sugars, becomes the starting point for tomato paste and most of the other tomato-based foods at your supermarket.

In the past 3 years, Weaver has produced lab and greenhouse tomatoes with about double the solids content of tomatoes typically raised for the processors' production line. That's a difference you probably can't taste. But it would show up as a "very significant benefit for growers and processors," notes Weaver, who is at the Western Regional Research Center, Albany, California.

Estimates from the tomato industry show that even a 1-percent increase in solids content could be worth $70 to $80 million a year.

Plant physiologist Merle Weaver examines tomato variants used in breeding high-quality, high-solids hybrids. (K-4274-12)

Better yet, some of the savings might be passed along to shoppers.

Lab techniques Weaver uses might work equally as well to pinpoint tomatoes that have other prized traits. Those qualities could include better flavor, a deeper red color, and juice that's naturally thick, not watery.

Right now, Weaver primarily tests tomatoes for processing. But he also investigates fresh-market tomatoes—the kind sold in the produce section. He works with both standard-size and cherry tomato varieties.

Most of today's commercially grown tomatoes have a solids content of about 5 to 5.5 percent. Yet some of Weaver's lab and greenhouse tomatoes boast a solids count of 8 to 12 percent. One measured an astonishing 15 percent.

Weaver is quick to point out, however, that growers and processors may have to wait another 2 years or more for these promising tomatoes. While some appear to be commercially acceptable already, others have glitches not found in well-established, widely planted commercial tomato varieties. For example, some test plants don't produce enough fruit or enough leaves to protect the fruit from sunburn.

To overcome these problems, plant breeders at Rogers NK Seed Company, a major supplier of farm and garden seeds and partner in the research, are hybridizing Weaver's experimental tomatoes with the company's own commercial breeding stock. Hopefully, the hybrids will inherit the best traits of each parent.

Weaver and technician J. Karen Burton find high-solids tomatoes by methodically screening test tube plantlets for this trait.

To produce plantlets, the researchers fill test tubes about one-third full with a gel-like mix of nutrients. Then they cut bits of leaves and stems from healthy tomato plants and place them atop the gel. Tissue that thrives forms shoots and roots and—later—tiny plants. The indoor culturing of tissue fosters changes—a phenomenon known as somaclonal variation. In this case, the variation the scientists seek is superproduction of solids when the plant matures.

Teamed with the strategy is another tactic: The researchers add a special mix of compounds to the culturing nutrients. Some or perhaps all of these ingredients, says Weaver, apparently interact with the plantlet's mechanism for producing solids. "We're not sure what happens," he admits, "but only the plantlets that can overproduce solids will survive and keep on growing. Those are the ones we keep."

By increasing the concentration of the blend, the researchers make survival tougher and tougher for plantlets. When the survivors bear fruit, the researchers test the tomatoes, keeping only seeds from those that have a solids content of 7.0 or better.

Neither lab technique—tissue culturing of tomatoes or exposing tissue to screening compounds—is new. But Weaver is likely the first to combine these approaches in a search for high-solids tomatoes.

Seeds from the best of these greenhouse tomatoes advance to outdoor trials. Weaver has relied on Herman Timm, recently retired from the University of California, Davis, to assist with these trials.

At Rogers NK Seed Company, tomato breeder John D. Prendergast directs outdoor tests of plants that are hybrids of ARS tomatoes and his company's best tomato breeding lines. Impressed with the potential of the experimental tomatoes, the company has entered its third year of collaboration with Weaver.—By **Marcia Wood,** ARS.

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SCOTT BAUER

With a digital refractometer, Merle Weaver measures soluble solids in field-grown crosses of high-solids variants and commercial tomatoes. (K-4274-7)

Seeking Solutions to Chayote's Sprouting

Chayote (commonly pronounced chy-O-tay) ranks as one of the world's most versatile vegetables. "It's delicious eaten raw, stir-fried, steamed, or baked," says Louis H. Aung, an ARS researcher who grew up eating chayotes picked fresh from vines in his family's own backyard.

Aung, with ARS' Horticultural Crops Research Laboratory in Fresno, California, wants to make this tropical favorite a familiar choice at the produce section of your local supermarket. His experiments may reveal ways to adjust shipping and storage conditions to suit chayote. Aung hopes to enhance the crop's freshness and flavor while prolonging its shelf-life during packing, shipping, and storage .

Typically marketed when it's about the size and shape of a mango, chayote "tastes a bit like a cucumber, but is crisper and lighter," says Aung. He likens the texture of fresh chayote to that of kohlrabi. When properly cooked, it is slightly firmer than cooked zucchini.

A member of the cucurbit family of melons, squashes, and gourds, chayote ranges from green to yellow to creamy white on the outside. Inside, it's usually the same color as the peel, only lighter. A vigorous vine can easily bear several dozen chayote.

And chayote is nutritious. High in fiber, it's also a good source of potassium, calcium, iron, and vitamin C.

In the United States, fresh chayote is a minor crop, grown commercially in warm-weather states like Florida, California, and Louisiana. Some backyard gardeners in those states grow their own. The hardy vines usually require little care.

We import nearly 8,000 tons of chayote each year, primarily from Costa Rica and Mexico, but also from the Dominican Republic and Guatemala.

Supermarkets with specialty produce sections sell chayote year-round, or nearly so. Another outlet is roadside produce stands. The vegetable may retail for about 65 cents to $2 a pound, or about 55 cents a piece, and up.

Chayote tastes a bit like a cucumber, but is crisper and lighter.

JACK DYKINGA

Plant physiologist Louis Aung examines a sprouted chayote. (K-4570-2)

In Louisiana, chayote is known as mirliton. Holiday meals often feature halved mirlitons filled with a seasoned shrimp and bread stuffing.

Aung expects ethnic populations from Asia or Central and South America—where it is a familiar part of the traditional cuisine—to increase the demand for fresh chayote in this country. He thinks the vegetable might also appeal to other consumers "interested in trying something different."

Aung and colleagues want to rid chayote of its only major drawback: its troublesome tendency for seed to sprout prematurely on the vine. Aung works with Charles M. Harris, Richard L. Emershad, David C. Fouse, and Roger E. Rij at Fresno. Chayote's seed looks something like a big white lima bean. It can sprout while the chayote is still maturing on the vine—or anytime after that, including while it's in the produce warehouse or on your kitchen counter.

The sprout emerges from a single large seed in the center of the vegetable. Eventually, it pokes through the top, forming a trailing, twining vine.

The curious ability to sprout while still attached to the mother vine is an unusual phenomenon known as vivipary. A botanical rarity, the trait occurs in only a few kinds of plants, including mangrove trees of tropical swamps.

To thwart chayote's erratic sprouting, the researchers want to arrest the seed's growth once the vegetable is harvested. To store up energy to sprout, the developing seed steals moisture and carbohydrates from the surrounding tissues—the part we would otherwise eat.

Without moisture, a firm, succulent chayote can become dry, tough, fibrous, and unappetizing. Drained of some of its sugar-rich carbohydrates, chayote may lose some of its pleasantly bland, often sweet taste.

If allowed to sprout, the chayote is unmarketable. "People think it has sat around too long, even though that might not be the case," says Aung.

In tests planned for the next 3 years, the scientists will scrutinize

firmness, carbohydrate levels, and other quality-imparting attributes of chayotes kept at a range of temperatures and humidities.

Preliminary studies of more than 150 chayotes indicated that 60°F—a little cooler than room temperature—will likely prove to be the ideal temperature for storing the vegetable. Chayotes held at that temperature for about 2 weeks didn't sprout. When the same chayotes were kept for a few more days at 78°F, however, they began to sprout.

Aung says the change in temperature—not unlike the changes that could occur when chayote makes its way from the storeroom to the produce display to your kitchen—apparently triggered sprouting.

Cooler storage led to chill-induced injuries. At 41°F—about the temperature of the typical home refrigerator—swollen, watery looking spots formed on the peel. Further studies may reveal secrets behind chayote's unpredictable sprouting and practical ways to protect the taste and texture of the harvested vegetable as it travels from grower to grocer. Those findings could in turn boost future marketing of this exotic crop.—By **Marcia Wood,** ARS.

Louis H. Aung, Richard L. Emershad, Charles M. Harris, David C. Fouse, and Roger E. Rij are with the USDA-ARS Horticultural Crops Research Laboratory, Postharvest Quality and Genetics Research Unit, 2021 South Peach Ave., Fresno, CA 93727. Phone (209) 453-3000. ◆

JACK DYKINGA

Plant physiologist Max Harris tests firmness of a mature chayote. (K-4568-1)

Featuring a Bloatless Legume

While they have many advantages, legumes—especially alfalfa—have one major drawback as a green forage: They often cause animals to bloat.

Bloat is the buildup of gas in the cow's stomach caused by the rumen bacteria. Unlike humans, cows can't burp enough to relieve the gas. Instead, they swell up like big balloons and, in severe cases, suffer cardiac arrest or suffocation.

So why not a bloatless legume? If ARS plant geneticist Paul Beuselinck is successful, increasing the use of a long-unappreciated legume with a picturesque name will help.

Birdsfoot trefoil contains a natural antibloating compound known as tannin. Tannins help cows digest their food more slowly. In the rumen, these compounds bind to plant proteins, making them resistant to breakdown by rumen-dwelling bacteria. This slows down the rate of digestion. Further protein breakdown occurs when the nutrients reach the intestine.

> **Bloat is the buildup of gas in the cow's stomach caused by the rumen bacteria.**

"This legume has just the right amount of tannins—not too much and not too little," says Beuselinck.

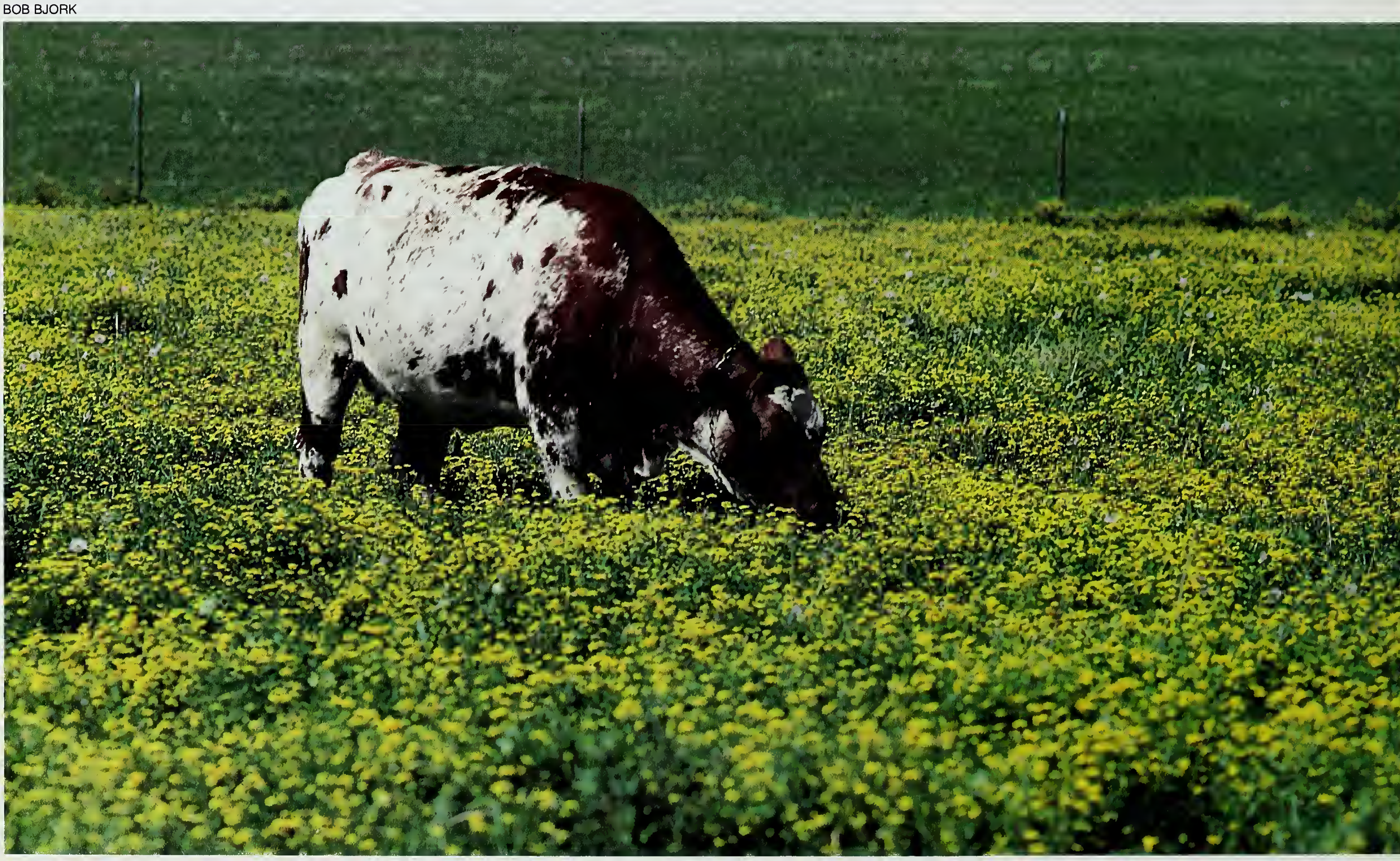
Tannins are so desirable that another ARS scientist, Allan Zipf, a molecular biologist in Logan, Utah, is trying to genetically engineer them into alfalfa.

His method is to coat tiny tungsten pellets with the DNA from sainfoin, a plant that's known to contain tannins. The pellets are loaded into a 22-caliber cartridge and blasted into alfalfa cells with a special gun.

Only a small percentage of the DNA ever makes it into the plant material, but if a lucky shot becomes permanent, alfalfa will start producing just the right amount of tannin. [For more on sainfoin, see *Agricultural Research,* February 1991, p. 18.]

In other research, Beuselinck found that birdsfoot trefoil and tall fescue grass make good companions. They

BOB BJORK



Birdsfoot trefoil contains tannin, a natural antibloating compound. (K-2610-10)

can be grown together, and together they produce a forage that's more nutritious for animals than just tall fescue alone.

Bacteria living on trefoil roots take nitrogen from the air and produce a nitrogen-containing protein that reduces the need for fertilizer for both the trefoil and the fescue.

"Trefoil looks like a fine-stemmed alfalfa with yellow flowers shaped like small sweetpeas. The plant tolerates poor soil conditions and abuse from grazing animals much better than alfalfa," says Beuselinck.

The plant has a taproot system, much like a carrot, only with branches. Birdsfoot trefoil has higher nutritional quality than alfalfa and doesn't decrease in quality as the plant matures the way alfalfa does.

Even with all its desirable qualities, birdsfoot trefoil doesn't enjoy immense popularity as a forage crop. That's because it's very susceptible to root disease. The answer to this problem, according to Beuselinck, may be linked to the plant's wild relatives from Morocco.

In 1989, Beuselinck collected wild birdsfoot trefoil in Morocco. Plants he found there have a unique rooting characteristic: the ability to develop rhizomes—underground runners—that allow the plant to spread to new areas. Then, even if the mother plant dies of disease, new stands of rhizome-producing trefoil would survive.

Beuselinck believes it is possible to move the genes for rhizomes into higher yielding American varieties through either breeding or genetic engineering.—By **Linda Cooke,** ARS.

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Forage Research Symposium

Forage digestibility is important to researchers and plant breeders throughout the world—so much so that the U.S. Dairy Forage Research Center sponsored an international symposium on forage cell wall structure and digestibility in October 1991. More than 150 researchers from the United States, Australia, New Zealand, and European countries attended to discuss increasing the digestibility of forages.

Some questions the symposium participants addressed include:

- **Is the amount of cell wall surface a limiting factor to digestion?**

"Yes," says Dwayne R. Buxton, a plant physiologist at ARS' Field Crops Research Unit in Ames, Iowa, "because bacteria have to digest the cell wall from the surface to the interior of the wall. Making the cell wall thinner could make it easier for bacteria to digest cell walls."

- **How important is the rate of digestion?**

"We have a limited amount of time (about 24 to 48 hours) before feed materials pass on from the digestive tract. So, rate of digestion is important to ensure breakdown before feed material exits the cow," says Buxton.

- **In lignified cells, must bacteria get inside cells before they can digest the cell wall carbohydrates?**

If this is necessary, mechanical shredding of plants to expose more of the cells to bacteria may improve digestion as well as aid drying rates.

- **Could the chemical composition of lignin be changed to make it less inhibitory to digestion?**

"Some cells become lignified, while others don't. If we knew what controls lignification of a cell, we could change lignin by changing its location within the cell. For now, we are attempting to identify what desirable attributes we want lignin to have," says Buxton.

A more detailed discussion of these and other questions will be published this fall in a book titled Forage Cell Wall Structure and Digestibility by the American Society of Agronomy, 677 S. Segoe Rd., Madison, WI 53711.

NURSERY NURTURE

New methods for increasing seedling survival

From the nursery to forests—or even to Christmas tree plantations—evergreen seedlings today are making their transitions with better survival rates than ever.

"There's a short live-or-die window for transplanted trees, particularly in southern Oregon and northern California, that occurs after the snow melts but before the soil becomes too dry," ARS' Robert G. Linderman says. He's a plant pathologist at the Horticultural Crops Research Unit in Corvallis, Oregon.

Tactics to enhance survival during that time would benefit reforestation projects throughout western states, where over 100 million conifers (cone-bearing species—including most evergreens) are replanted each year.

Linderman's earlier research demonstrated that one species of mycorrhizae, *Rhizopogon vinicolor,* helps Douglas-fir seedlings better tolerate and recover from drought. These fungi colonize the roots and help them take up nutrients and water from soil.

How do the fungi function? Although scientists aren't sure of the exact mechanism, companies like Weyerhaeuser and Georgia-Pacific have already begun safeguarding their conifer seedlings with the naturally occurring beneficial mycorrhizae.

Part of the answer has been suggested by recent studies. Linderman and graduate student Michael Dosskey say that *Rhizopogon* seems to help seedlings maintain photosynthesis—that is, conversion of sunlight into food—during drought.

Whereas feedback mechanisms normally tell plants suffering from lack of water or other stresses to shut down photosynthesis, the presence of *Rhizopogon* enables young tree roots to create a bigger reservoir, or sink, for products of photosynthesis, such as carbon.

"So the fungi encourage photosynthesis to continue, despite the drought. That keeps the plant healthy and functioning," says Linderman. "There

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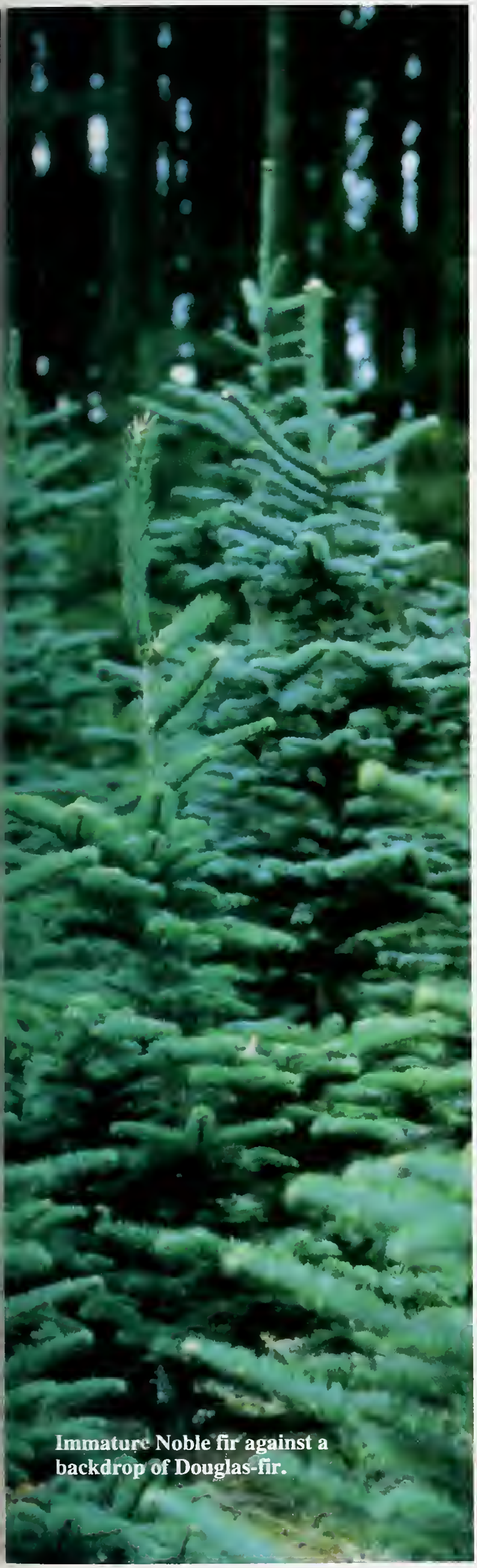

Immature Noble fir against a backdrop of Douglas-fir.

are probably other mechanisms involved. The final story isn't in yet."

In related work, he's shown that root growth in some evergreens—namely, Douglas-fir, Western hemlock, and Noble fir—may also be enhanced by ethylene, the so-called ripening gas.

Linderman, colleague John Blake of USDA's Forest Service in Aiken, South Carolina, and former graduate student Isabel Alvarez tested the theory by injecting different concentrations of ethylene into plastic bags that held the harvested seedlings in cold storage before spring planting.

Ethylene stimulates new roots to emerge from the seedlings' old roots. The gas—released naturally by fruits and vegetables as they ripen—also helped new buds open from branch tips more quickly. Both effects aided seedling survival after transplant.

For seedlings of blue spruce, a popular landscaping and Christmas tree, the secret to a good start in life may be an experimental chemical called DCPTA (2-(3,4-dichlorophenoxy) triethylamine).

USDA FOREST SERVICE

Seedlings survive from nursery to forest better than ever.

ARS researcher Henry Yokoyama at Pasadena, California, and colleagues Hideaki Kobayashi and James H. Keithly tested the chemical on about 200 blue spruce seedlings. Seeds soaked for 6 hours in the compound, then nurtured into seedlings at the Pasadena research greenhouse, were 51 percent taller than their untreated counterparts after 8 months.

What's more, the seedlings had 37 percent more root growth and 350 percent more branches than those from untreated seeds.

The most vigorous little trees were those exposed to DCPTA at a rate of 10 parts per million (10 ounces in 7,800 gallons).

Growth of stems, branches, and needles was in good proportion to buildup of the seedlings' root systems. That's important: If aboveground growth outstrips roots' slower pace, top-growth slows until roots catch up.

Yokoyama says that DCPTA likely accelerates photosynthesis, probably by altering two key pieces of the plant's photosynthetic machinery. It leads to better-developed thylakoid membranes, and larger choloroplasts. Scientists found that happened with spinach, one of more than a dozen crops the researchers have tested with DCPTA over the past 15 years.

Submersing seeds, or misting plants with a DCPTA spray, has yielded jumbo radishes, sugar beets that contain more sugar, and lemons richer in costly lemon oil essence. Yokoyama also credits DCPTA for bumper crops of tomatoes, beans, corn, and cotton.

DCPTA may be synthesized commercially in the future, but the compound must have federal approval before it is put on the market for plant nurseries or home gardeners to use. Yokoyama shares small quantities of it with other researchers. Among them are scientists in Southeast Asia who are seeking hardy teakwood seedlings to replant in denuded rain forests.—By **Julie Corliss** and **Marcia Wood**, ARS.

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BOB HENDERSON

A larva from this Asian lady beetle's egg will soon be a voracious feeder on the euonymus scale insects that cover the twig. (K-2848-12)

TIM McCABE

Red-spotted ladybug, *Chilocorus kuwanae*, devours euonymus scale insects. (K-2848-4)

Targeting Euonymus Scale for Biocontrol

Controls reestablish the natural balance, making the imported pest fight for survival.

It's a typical example of what is called classical biological control—introducing natural enemies of accidentally imported pests to help control them. Such controls reestablish the natural balance, making the pest fight for survival.

The latest example of this method may become another successful biological control program for pests of ornamental trees and bushes.

The natural enemies involved are a lady beetle and a smaller beetle, both imported from Asia. Their target pest: euonymus scale, *Unaspis euonymi,* which attacks euonymus plants and also feeds on some other types of ornamental trees and bushes.

"Scale insects fasten themselves to plants with their needlelike mouthparts, literally milking the plant dry of sap," explains John J. Drea, an ARS entomologist at the Insect Biocontrol Laboratory at Beltsville, Maryland. Drea has spent 8 years studying the natural enemies of scale insects. Now his work is paying off.

"Scale pests that attack euonymus plants rank among the most insidious enemies of trees and bushes in the United States," he says. "Many nurseries have stopped selling euonymus because they are so susceptible."

Euonymus rank twelfth among the 20 most common ornamental plants used in the multibillion-dollar landscaping industry. They can be deciduous or evergreen and grown for ground cover, hedges, ornamental vines, shrubs, or trees.

According to Drea, the scale can also infect 30 other types of ornamental plants including pachysandra, hibiscus, and camellia.

"A severe infestation can kill branches and the plant itself—a grave problem in established landscapes," Drea says. In a recent survey of Maryland homes, nearly 70 percent of euonymus had problems due mainly to the scale.

The female euonymus scale is slightly brownish, about 1/16 inch long and shaped like an oyster shell. As many as three generations of this pest can be produced in a year, depending on the climate.

As she grows, the female scale insect forms a hard waxlike armor—the scale—under which she lives and lays her many eggs. Since she has no legs, she never moves again.

In spring, scale eggs hatch and the offspring begin to crawl. About the size of a speck of dust, crawlers have legs and can move about the plant, eventually settling to feed on it.

Male insects form small white scale coverings when they settle to feed on plants. Eventually, tiny white-winged males develop under these covers and emerge as free-living adults that mate with sedentary females. Since adult males have no mouthparts, they cannot feed. They live for about a day.

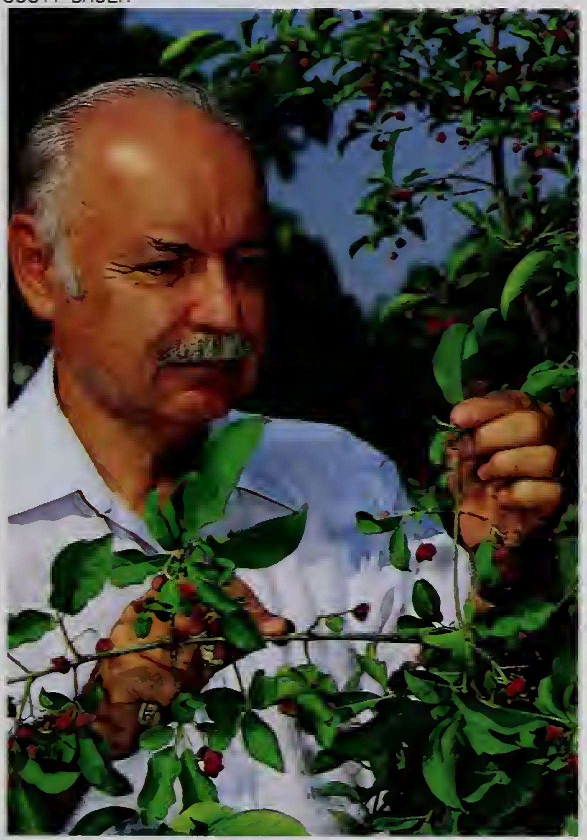
"The chemicals diazinon, carbaryl, and malathion are often used to control the scale. However, pesticides are effective only for a very short time during the insect's lifecycle. They are unable to penetrate the scale's armor," Drea says. "They also kill off any natural enemies that keep normally innocuous species under control."

Reuniting the natural enemies and scale pest was an epic adventure. "It has taken over 10 years and half a dozen cooperators in ARS and 30 outside the agency to get the biological control program to this stage," he says.

The story began in the early 1980's. Jack Coulson at the ARS National Biological Control Documentation Center in Beltsville included the euonymus scale as a target pest as part of a Small Farms Research Project.

"The project included controlling a group of economically serious scale pests like San Jose, white peach, and prunicola

SCOTT BAUER



Entomologist Jack Drea examines the undersides of euonymus leaves for scale. (K-4232-14)

scales whose family includes the euonymus scale," Drea says.

One of Coulson's tasks at the center was to develop a computer program on the movement and use of foreign and native biocontrol agents (insects, mites, nematodes, and pathogens such as fungi, viruses, and bacteria) in the United States. The center keeps track of these agents. The program, called ROBO (Release of Beneficial Organisms), makes this information available to state and academic institutions as well as to federal laboratories.

One of the growing database's many purposes is to provide historical information on natural enemies for introductions made in past decades. Such information helps scientists to re-evaluate these data for current biological control projects.

"Coulson realized over 10 years ago that the euonymus scale had never been a target for biocontrol activities," Drea says.

Since the scale is believed to be oriental in origin and probably came to the United States on nursery stock, Coulson requested the assistance of the ARS Asian Parasite Laboratory at Seoul, South Korea, to obtain natural enemies attacking the scale in Korea. Coulson was at that time the lab's technical adviser.

Entomologist Bob Carlson, now at the ARS Systematic Entomology Laboratory (SEL) in Beltsville, Maryland, was then a foreign explorer in charge of the Korea lab.

Once alerted, scientists there began the long process of examining the literature and museum specimens to uncover clues about the pest's enemies. They began exploring the Korean countryside for scale infestations, collecting its natural enemies for study.

Among these, they found two species of beetles. One was an Asian lady beetle, *Chilocorus kuwanae.* It is shiny black with a red spot on each wing cover or side. Both sexes look similar and are difficult to differentiate without a microscope.

The other beetle was a 1/25-inch-long nitidulid, *Cybocephalus prob. nipponicus.* The female is all black, while males have dull-yellow heads and black backs.

The two Asian beetles lay their eggs under the body of the euonymus scale and in cracks of the bark or other protected places on the host plant. When larvae hatch, they feed voraciously for about 3 weeks on the scale pest and their offspring.

The lady beetles' powerful jaws enable them to chew through the scale's

TIM McCABE

Euonymus scale insects encrust undersides of tree leaves (right), sucking their juices and killing the tree. (K-2849-11)

armor or to dig it out. The smaller beetles destroy the scale by burrowing under its covering to feed.

In 1982, Carlson shipped several beetles of both types to quarantine officer Larry Ertle at the ARS quarantine facilities at the Beneficial Insects Introduction Research Laboratory in Newark, Delaware. There, the shipment was carefully examined under a microscope to ensure that it contained only beetles.

After rearing one generation of the beneficial insects to eliminate any unwanted parasites, Ertle sent 50 to 100 offspring of both species to Drea in Beltsville for additional studies, culture, and release.

The job of officially identifying the two beetles—an essential part of introducing any natural enemy—went to entomologist Robert D. Gordon, who is located at a special SEL unit housed at the Smithsonian Institution's Museum of Natural History in Washington, D.C. University of Delaware entomologist William A. Connell, now retired, cooperated in the identification.

In 1983 and 1984, Drea reared and released both species and evaluated them in the United States. Once the colony was established, he sent several dozen beetles back to the Newark lab to former ARS entomologist Robert M. Hendrickson, Jr. He and assistant Sue Barth reared and released the insects there and in the immediate area.

The three then sent one or both types of beetles to more than 40 cooperators in 24 states in the eastern half of the country, to Washington, D.C., and to national laboratories in New Zealand and Italy. Recipients included state departments of agriculture, botanical gardens, zoos, and private organizations.

One of the first test sites was the U.S. National Arboretum in Washington, D.C. By 1985, this primary release site had become a natural insectary and the main source of both predatory beetles for later shipments to secondary release sites in Maryland, Delaware, Pennsylvania, New Jersey, and Washington, D.C.

From 1984 to the present, some cooperators have set up rearing and distribution programs in their states. Others simply released the beetles. Most have followed up on and monitored the success of the releases.

Field studies in 20 states have shown that the beetles "quickly took hold and all but eliminated the scale from many test plots," Drea says. "In several spots, the beetles decimated the scale population and then disappeared."

The beneficial beetles returned several years later when the pest reappeared. "Where the beetles went during the interim is not known," he says, "but they came back when they were needed. This is a tremendously positive sign. It's an ideal situation for biological control."

"Some of the people who cooperate with us in testing the beetles are extremely enthusiastic and see a great potential for them," Drea says. "Others ran into problems because homeowners and landscape gardeners removed the sick and dying bushes and the beetles disappeared. In some areas, ants tending honeydew-producing aphids perceived the beetles as threats to their food source and interfered with the beetles' establishment."

Because of the overall success of this research, USDA's Animal and Plant Health Inspection Service (APHIS) recently funded a national project for biological control of euonymus scale.

ARS, several universities, and private industry will cooperate in the project that will be coordinated by the APHIS laboratory in Niles, Michigan. It will include several species of tiny wasps and predators that also attack euonymus scale in Asia.

Other pests targeted by APHIS for control with these predators are white peach scale and San Jose scale, the most destructive scale pest of fruit trees.

Last spring, APHIS workers planted 500 plants representing three species of euonymus on a 1-acre site. They plan to deliberately infest the plot with scale to colonize populations of the pest's natural enemies.

"These natural enemies will be mass-reared, distributed, and evaluated throughout the United States," says Michael D. Bryan, who is with the APHIS National Biological Control Laboratory in Niles, Michigan. APHIS plans to support additional explorations to China to find cold-hardy strains able to withstand the northern U.S. climate.

"If successful, this project will demonstrate the tremendous potential for controlling nursery and ornamental pests using their natural enemies," Drea says. "This field of research—for nursery and ornamental pests—has received little, if any, consideration in the past."—By **Hank Becker,** ARS.

For more information on the biological control project, contact Michael D. Bryan, USDA-APHIS National Biological Control Laboratory, 2534 South 11th Street, Niles, MI 49120. Phone (616) 683-3563.

Jack Drea has recently retired. He may be reached at (301) 937-8250. ◆

Sodic Soil Problems?

Say "Cheese!"

To make poor soils more productive, waste products from cheese-making may be the whey to go.

ARS soil scientist Charles Robbins found that acidic whey—the watery, nutrient-rich liquid that separates from curds in cottage cheese production—may restore the health of high-sodium soils.

Known as "sodic," these soils pose serious problems for farmers in arid, irrigated regions like southern Idaho, according to Robbins, who is based at the Soil and Water Management Research Unit in Kimberly, Idaho.

The soils lack stable structure, or tilth. Water can't penetrate easily and simply flows off the surface, as if the soil were covered with plastic. Naturally, crops grown in these soils suffer from lack of water.

Over 1.8 million acres in the United States are classified as sodic, according to Dale A. Bucks, ARS' national program leader for water quality and management.

The unique composition of whey makes it an ideal supplement for sodic soils, Robbins found. Whey contains calcium, magnesium, phosphorus, and potassium, as well as sugars and proteins. The mixture helped restore soil tilth and boosted yields of barley in Robbins' initial greenhouse and small field plot tests.

To make cottage cheese, producers add concentrated phosphoric acid (or beneficial bacteria that produce the acid naturally) to a vat of milk. They then stir and heat it until the milk curdles. The remaining liquid is known as whey.

Robbins hit on the idea of using whey a few years ago while at a meeting about groundwater safety.

"I heard a talk about the problem of disposing of food-processing plant wastes," says Robbins. "When I saw the data on whey—how much the cheese factories produce, and what it's made of—it struck me that it might be a good treatment for our sodic soils."

Why whey? "The calcium, magnesium, and potassium present in whey actually replace the sodium in sodic soils. In addition, because whey is acidic (about the same pH as vinegar), calcium already in the soil is more soluble and will also replace sodium," explains Robbins.

Soil tilth improves, once the excess sodium is leached out. That in turn increases water infiltration in the soil, so thirsty plants can drink.

Other nutrients in whey, like nitrogen and phosphorus, also help nourish growing plants.

What's more, whey is abundant and inexpensive. For every pound of cottage cheese made, there are 9 pounds of whey produced.

According to Conly Hansen, a food engineer at Utah State University, cheese factories across the United States produce more than 2 million tons of whey each year.

Larger dairies dehydrate some of their whey and sell it to food companies. Dried whey protein is added to several food products like cake mixes, candies, and ice creams. And some whey ends up as livestock feed.

But a great deal—up to 50 percent—simply goes to waste, says Hansen. The factories actually pay to dispose of their excess whey through local sewage treatment plants, as is required by state environmental protection agencies or public health laws.

Robbins first tested the whey treatment in large plastic cylindrical columns in the greenhouse. The columns, known as weighing lysimeters, are a foot in diameter and about 3 feet tall, each holding about 300 pounds of soil. They enable researchers to precisely record weight changes from water (and whey, in this instance) added to the soil, to determine how much the plants use and how much is lost through evaporation. The lysimeters are equipped with sampling ports that allow him to collect subsurface water draining from the columns and analyze it for sodium and other compounds.

The control treatment (no whey) produced barley that didn't "fill," or produce grain. The best whey treatment yielded barley at a rate equivalent to 42 bushels per acre. With continued whey treatments, that could improve up to 80 bushels per acre, says Robbins.

Outdoor field trials have shown similarly positive results. For those tests, Robbins applied the whey to the field using plastic irrigation pipes. It can't be run through aluminum pipes, because its acidity would eventually dissolve the metal.

Whey applications were made during the spring and late fall and plowed into the soil immediately before planting. It's usually quite cool at those times of year, so there's no odor problem.

Robbins is also testing the use of whey on eroded and leveled nutrient-poor soils. Such areas may suffer productivity losses up to 50 percent.

He's comparing two different whey application levels with manure and conventional fertilizer, on exposed subsoils. Three different crops—alfalfa, forage sorghum, and dry pinto beans—will be grown in different rotations on the plots.

These long-term studies should help researchers determine the optimal amounts of whey to use for restoring soil physical conditions and crop productivity, according to Robbins.

"I'm very excited about the idea," says food engineer Hansen. "This is one solution to our whey disposal problem that seems to have great possibilities."—By **Julie Corliss,** ARS.

Charles W. Robbins is in the USDA-ARS Soil and Water Management Research Unit, 3793 N, 3600 E, Kimberly, ID 83341. Phone (208) 423-6530. ◆

Diagnosing Pseudorabies

New genetic information on swine disease is progress toward eradication

Pseudorabies is a highly contagious livestock disease, most prevalent in pigs. It's called pseudo (false) rabies because of its rabieslike symptoms—mouth frothing, teeth grinding, changes in temperament, and a chokelike spasm of the esophagus.

Pseudorabies is sometimes called Aujesky's disease after the Hungarian scientist who first described it and identified the causative virus in 1902. Mad itch is yet another name for pseudorabies because infected animals suffer intense itching, as well as other symptoms.

It's no surprise that the U.S. pork industry would like to eradicate pseudorabies by the year 2000; the disease costs U.S. pork producers about $60 million each year.

Several states have begun eradication programs. Iowa, the largest pork producer, has a pseudorabies control law that bans movement of infected animals into noninfected herds. Complete control of the disease is hampered by the virus' ability to go dormant or latent in swine.

Most farm animals and others found around farms—dogs, cats, rats, and mice—can be infected with the virus. Infection of these animals almost always results in death. Fortunately, humans are not susceptible to the pseudorabies virus.

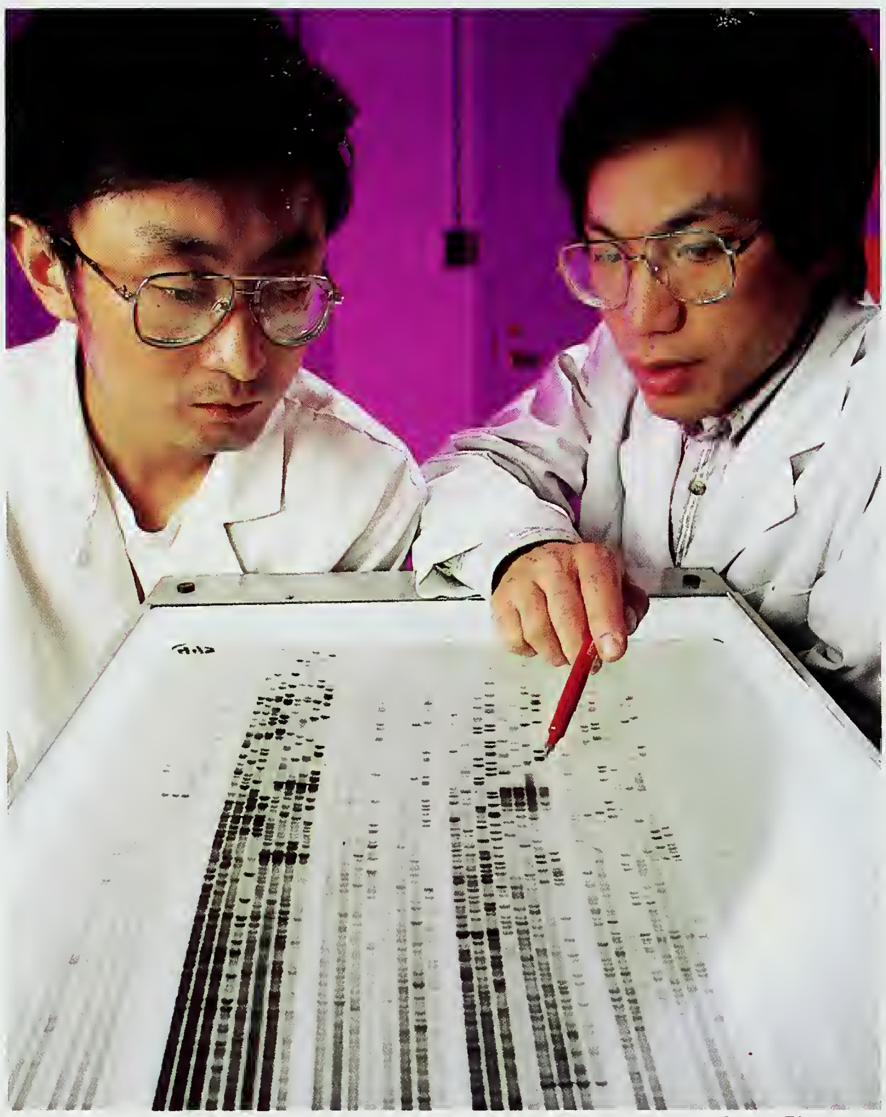
In a herd of pigs, the first sign of pseudorabies may be aborted litters. That's because the virus has the ability to cross the placenta and infect the unborn fetus. In young pigs, pseudorabies often causes sudden death. Older hogs usually survive infection, but they remain latently infected carriers of the virus.

During latency, the virus no longer multiplies, but its genetic information persists in the infected cell.

If the story ended here, latency might be of little more than academic interest. However, for reasons not yet fully understood, the virus sometimes reactivates and begins to multiply again. As a result, it can spread to other animals.

"Latency of the pseudorabies virus is a major obstacle to disease control and eradication. Pigs latently infected with pseudorabies virus aren't as easy to detect as those with active infections," says William L. Mengeling, who is in charge of Virology Swine Research at ARS' National Animal Disease Center in Ames, Iowa.

SCOTT BAUER



Microbiologist Andrew Cheung (left) and graduate student Jing Fang analyze the genetic code of pseudorabies virus. (K-4582-3)

ARS microbiologist Andrew Cheung, working with Mengeling at NADC, has provided a piece of the pseudorabies puzzle that could eventually contribute to eradication.

Cheung was the first to identify a gene that codes for messenger RNA that is present when the virus is latent in pigs. He refers to the mRNA as the large latency transcript. This transcript is made only during the latent stage of the virus.

The information Cheung has obtained is helping him to further understand what causes the virus to establish and maintain itself in infected cells and what causes it to become reactivated.

Until now, scientists have lacked the diagnostic tools to confirm latency of pseudorabies. With the genetic information that Cheung has discovered, scientists can use a polymerase chain reaction (PCR) technique to multiply the DNA sequence that codes for the large latency transcript.

Multiplication is important because the amount in latently infected animals is very low. The PCR method can be used alone or with gene probes to identify carrier pigs.

"Ideally, we'd like to develop vaccines that prevent the virus from becoming latent so animals recovering from infections won't become carriers. But such an accomplishment is futuristic," says Cheung.

In other studies at NADC, Mengeling and veterinary co-workers Kelly Lager, David Volz, and Susan Brockmeier found that disease-

producing (virulent) strains of pseudorabies virus and presently used vaccines can establish latent infection in the same pig and then be reactivated simultaneously.

"This chain of events can set the stage for virus recombination. Pigs so infected could spread a virulent virus that can't be differentiated from the vaccine virus by marker-specific diagnostic tests. Such conditions would make eradication even more elusive," says Mengeling.

Besides helping the pseudorabies eradication program, the information Cheung has provided about latency of the pseudorabies virus could be used to study herpes simplex viruses in humans. "The latency gene may be in it too, but no one has identified it," says Cheung.

People become infected with herpes simplex type I that causes fever sores as well as the herpes simplex virus type II that produces genital lesions. Another related virus (varicella) causes chicken pox in children. It also becomes latent and re-emerges as the herpes zoster virus, causing shingles in adults. The same process occurs in pigs when the pseudorabies virus becomes reactivated.

"While pigs don't have lesions, they shed the virus silently, thus keeping the chain of infection going. We think the latency process is similar in people, and the genetic factors may likely be the same," says Cheung.—By **Linda Cooke, ARS.**

Andrew Cheung, William L. Mengeling, Kelly Lager, David Volz, and Susan Brockmeier are located in the USDA-ARS Swine Virology Research Unit, National Animal Disease Center, P.O. Box 70, Ames, IA 50010. Phone (515) 239-8324. ◆

SCOTT BAUER

Biological lab technician Ann Vorwald retrieves a pig tissue sample from storage for use in a polymerase chain reaction study. (K-4581-18)

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Veterinary medical officer Susan Brockmeier examines a pig that has been vaccinated to prevent pseudorabies. (K-4594-7)

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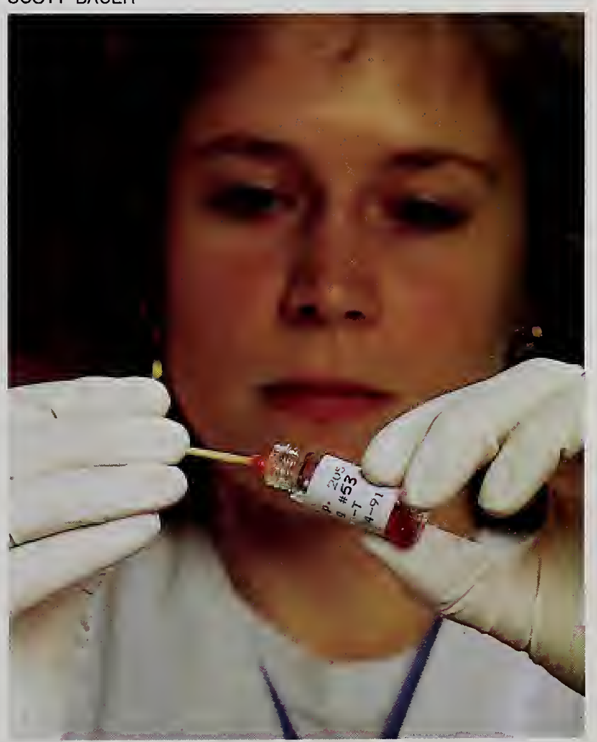

Biological lab technician Theresa Rahner selects a tissue sample for a polymerase chain reaction study. (K-4580-18)

One-Two Punch for the Woolly Apple Aphid!

The vexatious little woolly apple aphid has no taste discrimination. Apple roots á la carte are just as appealing as tender, juicy young apple stems, apple tree bark, or apple sap from tree trunks. So it does just as much—if not more—damage underground as it does above.

In addition to attacking mature orchards, the aphid also reduces yields during the first few years of a new orchard, a time when growers desperately need a maximum return on their investment. It can also devastate nursery stock.

"With the proper chemicals, we can easily control this pest on apple tree branches and trunks," says ARS entomologist Mark W. Brown. "But root nibblers are not easily managed."

Easy or not, Brown found two methods that work. A parasitic soil nematode and a new, systemic aphicide proved their worth in purging the pest in both lab and field tests.

"We got about 80 percent control with the aphicide; the nematodes were also significantly effective," Brown says.

In field tests at the ARS Appalachian Fruit Research Station in Kearneysville, West Virginia, he sprayed more than 3-1/2 million parasitic nematodes *(Steinernema carpocapsae)* directly into soil around trunks and root sprouts of each apple tree.

Nematodes can also be applied as a topdressing mixed with peat moss.

Brown mixed the aphicide, called RH-7988, with water and used it as a foliar spray and as a soil drench. The aphicide was supplied by cooperator Jules J. Jaeger, of Rohm and Haas Co. in Midlothian, Virginia. BioLogic Company of Willow Hill, Pennsylvania, commercially produces the nematodes. BioLogic employee Albert Pye also worked with Brown on the tests.

Native to eastern North America, the woolly apple aphid is a worldwide pest that also attacks elm. It causes damage by leaving honeydew on fruit, infesting apple cores, reducing tree vigor, attacking wounds on branches and tree trunks, and destroying roots. It's the root wounds that are most serious; they can kill the tree.

A fluffy, white woolly covering over most of the insect's posterior end accounts for its name. It lays eggs on the bark of elm trees in fall, but if elm is not available, apple will do. Wingless, parthenogenic (nonsexually reproducing) females emerge in the spring to establish colonies.

Some of the six stages of the insect drop to the ground, burrowing to tree roots to eat. In the fall, the winged pests fly back to the elm and give birth to sexual forms that eventually mate. Each female lays a single egg that can overwinter on the elm. Nymph forms can also overwinter, but on tree roots. Although frost usually kills the aboveground colonies, a soil covering protects the root dwellers, allowing continuous infestation.—By **Doris Stanley,** ARS.

Mark W. Brown is at the USDA-ARS Appalachian Fruit Research Station, 45 Wiltshire Road, Kearneysville, WV 25430. Phone (304) 725-3451. ◆

Tapping Annual Medics for Forage

Annual medics aren't exactly a household word in the United States, but Gary Bauchan wants them to play a higher profile role as a forage crop here.

Bauchan, a plant geneticist with the ARS Soybean and Alfalfa Research Laboratory in Beltsville, Maryland, has been working to tap the benefits of annual medics—which, like their alfalfa cousins, are members of the *Medicago* genus. A key difference is that alfalfa is a perennial crop, while some annual medics have to be seeded each year.

While not planted extensively in the United States, annual medics are grown on about 74 million acres in Australia, playing a key role in sustainable agriculture there, he says. Like alfalfa, annual medics are legumes, which—in tandem with soil bacteria—replenish the soil by taking nitrogen out of the air and putting it into the soil.

But the annual medics grown in the warmer Australian climate may not be suitable for this country, making further breeding essential. So, in cooperation with University of Maryland researchers, Bauchan has sifted through 1,220 annual medics samples selected from the 3,159 stored in the ARS collection in Pullman, Washington.

They evaluated the 1,220 samples for 18 key agronomic traits, such as forage yield, growth habit, pod production, and flowering date. Using a computer analysis, they selected 210 accessions, or samples, as a core collection for breeding.

Bauchan is now waiting for evaluations of the collection from field trials at five locations across the United States—Beltsville; Logan, Utah; Pullman; St. Paul, Minnesota; and Tucson, Arizona.

"Until now, the potential of annual medics has been largely untapped in this country," Bauchan says. "Now that we have the new collection, plant breeders will have a much easier task of sorting out the species that hold the most potential."

One that is promising, called *M. scutellata,* has glandular hairs along its stem that block alfalfa weevils from inching their way toward the plant's leaves. Without the leaves as food, the insects starve on the stem.

Since alfalfa has smooth stems, Bauchan and other scientists have tried to breed the hairy stems into alfalfa. So far they've had limited success, but Bauchan says it may be possible in the future using new genetic engineering techniques.—By **Sean Adams,** ARS.

Gary R. Bauchan is at the USDA-ARS Soybean and Alfalfa Research Laboratory, Room 323, Bldg. 001, 10300 Baltimore Ave., Beltsville, MD 20705-2350. Phone (301) 504-6649. ◆

Leaner Chickens Through MRI

Looking at the contour lines on the computer screen, you would never know it was the image of a sleeping chicken or that the image may lead to broiler chickens with leaner meat.

The modern broiler chicken was bred to produce more muscle mass, particularly in the breast, which is the most economically valuable part of the bird. In the process, the chicken became fatter.

Even though chicken is still considered relatively lean, scientists believe it can be made leaner. Chickens have a great deal of fat tied up in a triangular body in the abdomen, "which costs the poultry industry about $500 million annually in waste. Additional fat is found under the skin," says ARS animal scientist Alva D. Mitchell.

Magnetic resonance imaging, or MRI, a handy diagnostic tool for doctors, is making inroads into animal research. MRI can be used to visually dissect living tissue without harming the animal.

"With MRI's three-dimensional cross-sectional images, we can follow the muscle and fat development in a chicken from hatching until it reaches market weight. At the end of the test, the bird will still be around to breed," says Mitchell who does his research at the Non-Ruminant Animal Nutrition Laboratory in Beltsville, Maryland.

The birds are anesthetized to keep them motionless in the test chamber where they are surrounded by a magnetic field. Changes in the field, induced electronically, help differentiate the tissues. An image is displayed on a screen and printed on X-ray film. A series of images can be translated into three-dimensional form, which is displayed on a color computer monitor.

"The images of the various tissues are electronically tinted to better visualize them. On the screen, the image can be moved around to see the tissue from all angles," says Mitchell.

The MRI machine can also be used as a spectrophotometer, an instrument for measuring elements. "In this mode, it is possible to measure total fat and water content of the entire bird," says Mitchell.

Use of MRI in agricultural research is in its infancy. For now, "the practical application of MRI is limited by the expense of the instrument. The small research unit used in these tests cost about a million dollars," says Paul C. Wang of the Department of Radiology, Howard University Hospital, Washington, D.C., who cooperated in the tests conducted at the university's facility.—By **Vince Mazzola,** ARS.

Alva D. Mitchell is at the USDA-ARS Non-Ruminant Animal Nutrition Laboratory, Beltsville Agricultural Research Center, 10300 Baltimore Ave., Beltsville, MD 20705-2350. Phone (301) 344-2868. ◆

What's a Better Blueberry Pollinator?

A wild bee with a metallic green body could mean more blueberries on growers' bushes.

Blueberries, like most fruit crops, require cross-pollination to ensure a good fruit set. It's a bit tricky, however, for the average honey bee to get pollen from blueberry blossoms—which are shaped like an upside-down vase with a very narrow opening.

Not so for the slightly smaller *Osmia ribifloris.* This native bee has a unique foraging technique that's well adapted for nabbing pollen from such flowers, says Philip Torchio, an entomologist based at the ARS Bee Biology and Systematics Laboratory in Logan, Utah.

"As the female probes for nectar, she thrusts her front legs inside the blossom, knocking pollen off the anthers onto her legs," Torchio explains. En route to the next flower, she grooms herself, moving the pollen to her abdomen and hind legs.

The next flower she visits will likely contact that pollen because the flower's stigma protrudes out from the blossom. That's how cross-pollination is achieved.

Torchio trapped and studied the wild bees as part of a longstanding program aimed at finding alternative pollinators for crops.

The *O. ribifloris* species came from seven locations in the coastal mountains of southern California. There, the bees gather their pollen from manzanita—a shrublike tree with thin, reddish-brown bark and flowers that closely resemble those of the blueberry.

PHILIP TORCHIO

***Osmia ribifloris,* a wild green bee with a unique foraging technique.**

Blueberries, Torchio points out, belong to the Ericaceae family, as does the manzanita. "That's why we thought we'd test these bees on blueberries," he says.

Torchio released more than 1,500 bees on a highbush blueberry plantation in northern California. He found that the bees visit one blueberry blossom about every 3 seconds. "That's about three times as fast as a worker honey bee," he notes.

He also sent a few hundred *O. ribifloris* pupae to colleague Eben Osgood, an entomologist at the University of Maine. Osgood kept the bees in cold storage and put their nests out in May, just as the lowbush blueberries native to Maine were beginning to blossom.

"These bees work from daylight 'til dark, even on drizzly days," says Osgood. And he notes the bees were very selective about which species they would visit.

Analysis of pollen from the bees' nests showed that more than 95 percent came from blueberries despite the fact that there were over 50 different flowering plant species in the vicinity, including wild strawberries and pin cherries.—By **Julie Corliss,** ARS.

Philip Torchio is at the USDA-ARS Bee Biology and Systematics Laboratory, Utah State University, Logan, UT 84322-5310. Phone (801) 750-2520. ◆

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